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Monitoring Electric Power Wheelchair Battery Consumption Level via Mobile

Ahmad Afiq Ahmad Shaiful[1], Romiza Md Nor[2*], Huzaifah A Hamid[3]
[1,2] Faculty of Computer and Mathematical Sciences
[3] Academy of Language Studies
Universiti Teknologi MARA, Perlis Branch, Arau Campus, 02600 Arau, Perlis, Malaysia

*Corresponding author: *romiza@uitm.edu.my*
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ABSTRACT

Power wheelchair is one of the most important vehicles for people with physical disabilities such as paralysis, stroke, handicap and many more. Electric wheelchair which is also called electric-power wheelchair or powerchair can be moved by an electrically based power source, regularly motor or batteries. It is very important to have frequent monitoring battery level because power wheelchair need sufficient battery level for it to be moved around. Therefore, this project is developed to monitor the battery consumption level and real time battery monitoring. Current sensor is used to measure the current state of the battery level. In this project, Internet of Things (IoT) concept is applied where sensor and mobile application is integrated and known as BLife. Blife was designed using the visibility of the system status principles which consist of knowledge is power, appropriate feedback, compel user to action and communication creates trusts. If the battery is in the lower state, the power wheelchair users will be informed through mobile application via an indicator informing that it needs to be recharged. Moreover, the current location of the power wheelchair user is also notified to the users' caretaker. Evaluation of Blife were conducted using functionality and usability testing based on visibility of the system status technique. Most of the respondents are satisfied and gave positive feedback. This project is a great contribution to disable people who has limited access to charge battery and to alert them on their battery level status.

Keywords: *Power wheelchair, real time battery monitoring, current sensor, Internet of Things, visibility of system status*

INTRODUCTION

Nowadays, power wheelchair is one of the most important vehicles for people with physical disabilities such as paralysis, stroke, handicap and many others. According to DiGiovine (2014), electric wheelchair, is also called electric-powered wheelchair or powerchair which has any seating surface with wheels fastened to it that is moved by an electrically based power source, regularly motors and batteries. Thus, it is important to monitor the battery level of the power wheelchair. This is because the power wheelchair needs sufficient battery capacity in order for it to operate. The battery needs to be monitored so that user can make assumption or expectation based on the latest battery capacity. For example, if the capacity of the battery is 50%, the user will be able to gauge the distance that the power wheelchair can operate. According to Beheshti (2018), the battery needs to be monitored in order to deliver a profitable result.

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The main purpose of this project is to develop a prototype of real time battery monitoring using current sensor in order to notify user via mobile application known as BLife and to evaluate the effectiveness and efficiency of the prototype of real time battery monitoring. This project focuses on monitoring the battery consumption level of the power wheelchair using the current sensor. The significance of this research is that it can greatly contribute to the welfare of the disable people who have limited access to charge battery. Hence, power wheelchair users will be notified on the current state of the battery and the process of monitoring and charging the battery will also be faster. In addition, power wheelchair users can know the exact capacity of the battery level and can monitor the process of the charging and discharging of the battery.

Therefore, to have a real time monitoring battery level that is integrated with the IoT, GPS module is used as the notification medium within the monitoring battery level system. In the context of this project, when the capacity of the battery is low, the caretaker will be notified on the location of the power wheelchair user through their mobile phone.

RELATED WORK

Power wheelchair uses a lithium ion battery as a source of power for moving wheelchairs. The power wheelchair battery needs to be monitored to aid the user about the process of charging and discharging of the battery. One of the benefits in monitoring the battery consumption level is to prevent the outages of the battery. According to Kaundart (2018), the capability to avoid numerous power-related outages is the primary benefit of monitoring battery. As stated by Eye (2018), battery monitoring provides confidence that the batteries will be dependable during an outage as maintaining and monitoring stationary battery systems is critical to maximize the performance and life of substation, UPS, and other critical backup power systems.

The monitoring of the battery is crucial in order to avoid problems that may occur to the battery when it is not being monitored. One of the problems is that the battery will experience failure and outages. In the case of most power wheelchair, the power wheelchair user can be stranded at some places because the battery of the wheelchair is low thus limiting the user's independence and access to environments (Furukawa Electric Co. Ltd., 2012). Moreover, most wheelchair user needs to make sure that the battery is in the charged state. This is because most power wheelchairs require two rechargeable 12-volt batteries (Furukawa Electric Co. Ltd., 2012).
Real time battery level display refers to the current capacity of the battery that is displayed to the users. In the context of the project, the prototype which is BLife displayed the battery capacity through the LCD display and mobile application.

METHODOLOGY

This research methodology has several phases which include planning, data collection, design and development, and evaluation. In the planning phase, the objective of this research is determined, the scope is identified, and a problem statement was stated to propose solutions for the project. Many resources have been explored such as journals, articles, books, online resources and many more to gather required information about the project. The process of data collection started from current sensor used to measure current flow and battery capacity. Current sensor detected the current state of the battery either low or high. The measurement of the capacity is based on the formula, whereby the power P of an electrical device is equal to voltage V multiplied by current I: $P = V * I$. While energy E is equal to power P multiplied by time T. Therefore, to find the energy stored in a battery is to multiply both sides of the equation by time:

$$E = V * I * T$$

Next, amp hours are a measure of electric charge Q (the battery capacity). Hence, the final version of the battery capacity formula looks like this:

$$E = V * Q$$

E: the energy stored in a battery, expressed in watt-hours, **V**: the voltage of the battery, **Q**: the battery capacity, measured in amp hours.

Thus, the capacity of the battery is low when the voltage of the battery is below their current state. Capacity of the battery is displayed via BLife. This shows the technique of visibility of system status that reflects the user's awareness of power status of his or her wheelchair. Each of the element technique describes the designing of BLife. Principles of visibility of the system status refers to the notion of **knowledge is power;** user can know their battery capacity when it is being monitored by the current sensor by looking on the website, which then create awareness to the user. Next is **appropriate feedback;** whenever users interact with a system, they need to know whether the interaction was successful. Appropriate feedback for a user action is perhaps the most basic guideline of user-interface design. It serves to keep users informed of the status and to allow them to steer the interaction in the right direction, without wasting effort. In the context of this project, the user will be informed about the battery capacity when the battery is low. Then, it **compels users to action;** notify the user about what action needs to be done. It also encourages user to take a positive action to improve their life. In the context of this project, if the battery capacity is low, the user will be notified to recharge the battery. Lastly, **communication create trusts;** sites and apps should clearly inform users of the state of the system – no action with consequences should be taken for users without informing them. If an external event or the passage of time caused a change in the state of the system, briefly but understandably explain it.

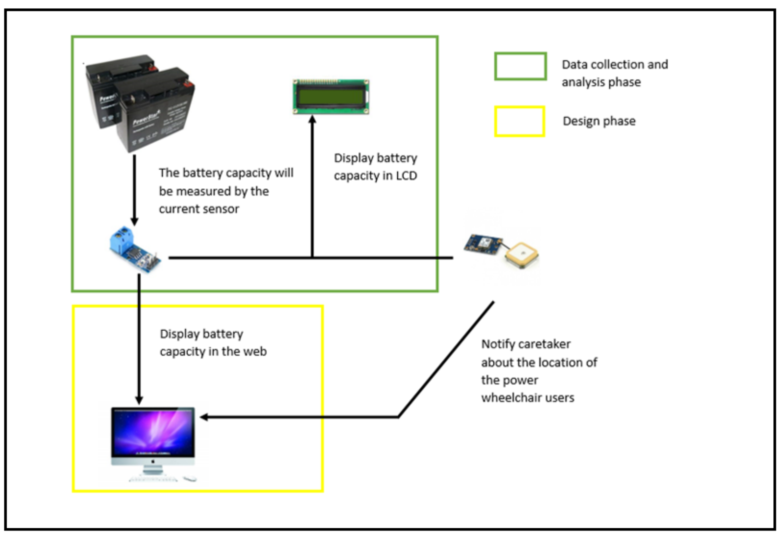

Figure 1: Experimental design of BLife

Next is design phase which is shown in the experimental design that is illustrated in Figure 1. It shows the flow and operation of the monitoring battery consumption level using current sensor. As the hardware, it used the current sensor, Arduino board, breadboard, GPS module and LCD display. In the context of this project, a prototype was designed and developed to measure the capacity of the battery using the current sensor. Figure 2 clearly shows how the current sensor measured the battery capacity and displayed it on the LCD panel and the result was displayed via mobile application, BLife. The location of disable user and status of battery level (low or empty) are notified to caretaker via the GPS module. Figure 2 shows the prototype of Blife.

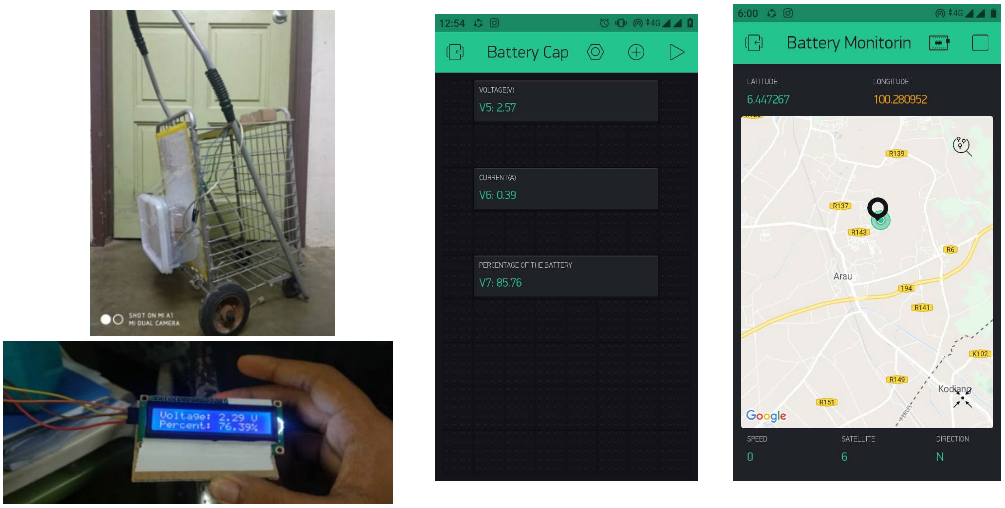

Figure 2: The prototype of BLife

Next is implementation phase where power wheelchair battery is configured with current sensor, GPS module, connector wire as mention in design phase to monitor the battery capacity of the power wheelchair. Lastly is evaluation phase, where BLife was evaluated using functionality testing and usability testing. Results is discussed in next section.

FINDINGS AND DISCUSSION

The criteria set in the evaluation were much related to system usability based on visibility of system status principles which are knowledge is power, appropriate feedback, compel users to actions and communication create trusts. Twenty respondents evaluated Blife. Each criteria was rated using a scale of Strongly Disagree (1) to Strongly Agree (5). All criteria received a mean score of above 4, which indicated that generally, BLife received good evaluation.

From the system usability evaluation, respondents raised concerns and recommended their solutions to improve the BLife. One of the improvements suggested was related to the interface design for the users to increase the user experience. For example, adding the color indicator to display the percentage capacity of the battery and sound or notification to create more awareness since users are busy maneuvering the wheelchair. Besides, more tips can be considered for example tips to increase durability of the battery in enhancing the battery capacity life. Moreover, when the users see the current capacity of the battery, it will force them to take some action if the capacity is low. Since the users of power wheelchair are disable, Blife functions to display the GPS location of the user to his or her caretaker. Therefore, the accuracy of the GPS location displayed is essential. Apart from that, most of the respondents were satisfied with the communication between the users and caretaker based on the GPS location displayed on BLife.

CONCLUSION

BLife is a prototype that was developed to monitor the battery consumption level and display the information such as the battery capacity on the mobile application. The main objective of this study which are to develop a prototype to monitor the battery consumption level using current sensor and evaluate the effectiveness of the prototype have been achieved. The main strength of BLife is on the context of the mobile application that can display the current capacity of the battery to the users. GPS tracker is also

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integrated to track the location of the power wheelchair users if the capacity of the battery is low to help the caretaker to know the location of the power wheelchair users. BLife can be enhanced by providing users with a lot more information such as tips, emergency direct contacts and notify caretaker immediately using short message service.

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CONFLICT OF INTERESTS DECLARATION

The authors declare no conflict of interests regarding the publication of this article.

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